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Title: Radiation released from the Decay of U-232 and U-233

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Annual Student Presentation

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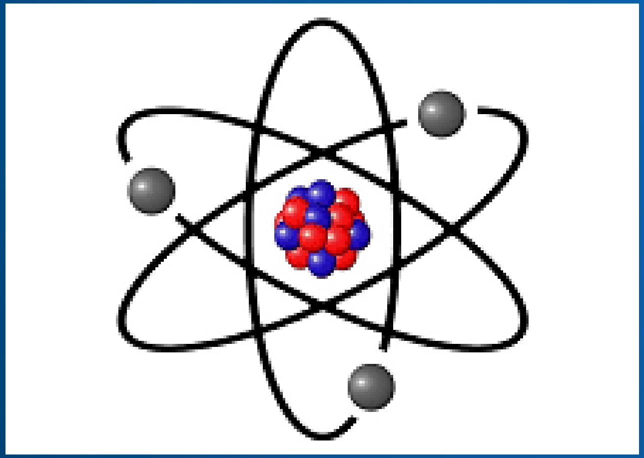
NNSA National Nuclear Security Administration

Introduction

- I currently am working on my bachelors degree in Nuclear Engineering at the University of New Mexico.
- I am from Veguita, New Mexico. (1 hour south of Albuquerque)
- I have 3 sisters and 1 brother.



Background

- When isotopes decay they release a variety of things from alpha particles to gamma rays.
- We are only concerned with the gamma and x-rays emitted due to them causing ionizing radiation and needing shielding.
- When U-232 and U-233 decay they emit large amounts as well as high energy gamma rays.
- As the energy of the gamma ray increases the thickness of a shield required to stop it also increases.
- The reason we are doing this project is the safety of workers handling the samples in the glove box. (ALARA)

Dosage

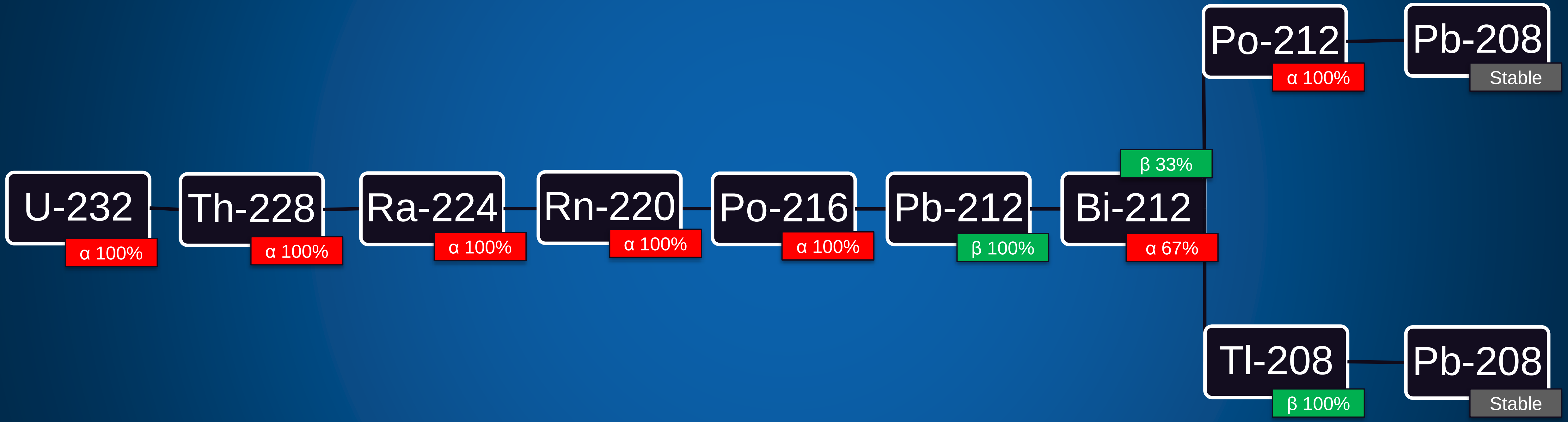
- We are looking at the dosage of radiation of the decaying isotopes for safety concerns.
- After the dosage has been determined we are then able to identify the amount of time that a worker can be exposed to the material and stay beneath the recommended dose.
- Theses gamma rays are of concern because they are what cause ionizing radiation.
- The gamma rays of most concern range from 0.08 MeV to 2 MeV. Although there are many released at lower energy levels, they are easily shielded.

Hand Calculations

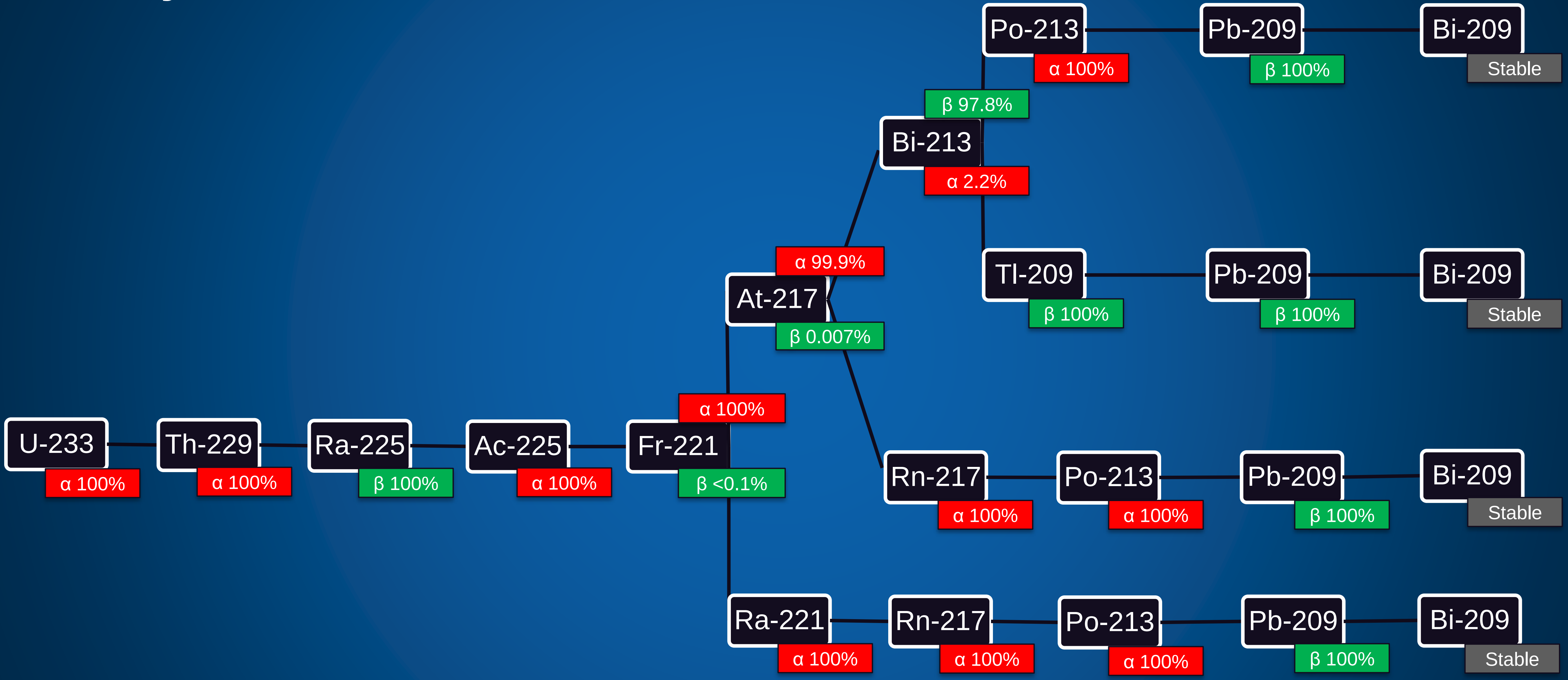
- To begin the hand calculations we must first look at the decay scheme and branching ratios of the isotopes.
- We then must look at the gamma and x-rays emitted from each decay.
- Calculate the Specific Activity of each Isotope. SA=$\frac{N_A \lambda}{M}$
- We then worked on calculating the specific gamma constant against the Oak Ridge National Laboratory (ORNL) data.
- $\Gamma = \frac{1}{4\pi R^2} \sum S_i D(E_i)$
- S= probability of gamma
- D(E)= dose rate per unit flux
- $ln\big(D(E)\big) = A + Bln(E) + C(ln(E))^2 + \mathrm{F}(ln(E))^3$

Photon Energy (MeV)	A	B	C	F
0.01 to 0.03	−20.477	−1.7454		
0.03 to 0.5	−13.626	−0.57117	−1.0954	−0.24897
0.5 to 5.0	−13.133	0.72008	−0.033603	
5.0 to 15.0	−12.791	0.28309	0.10873	

Decay Scheme of U-232



Decay Scheme of U-233



ORIGEN-ARP

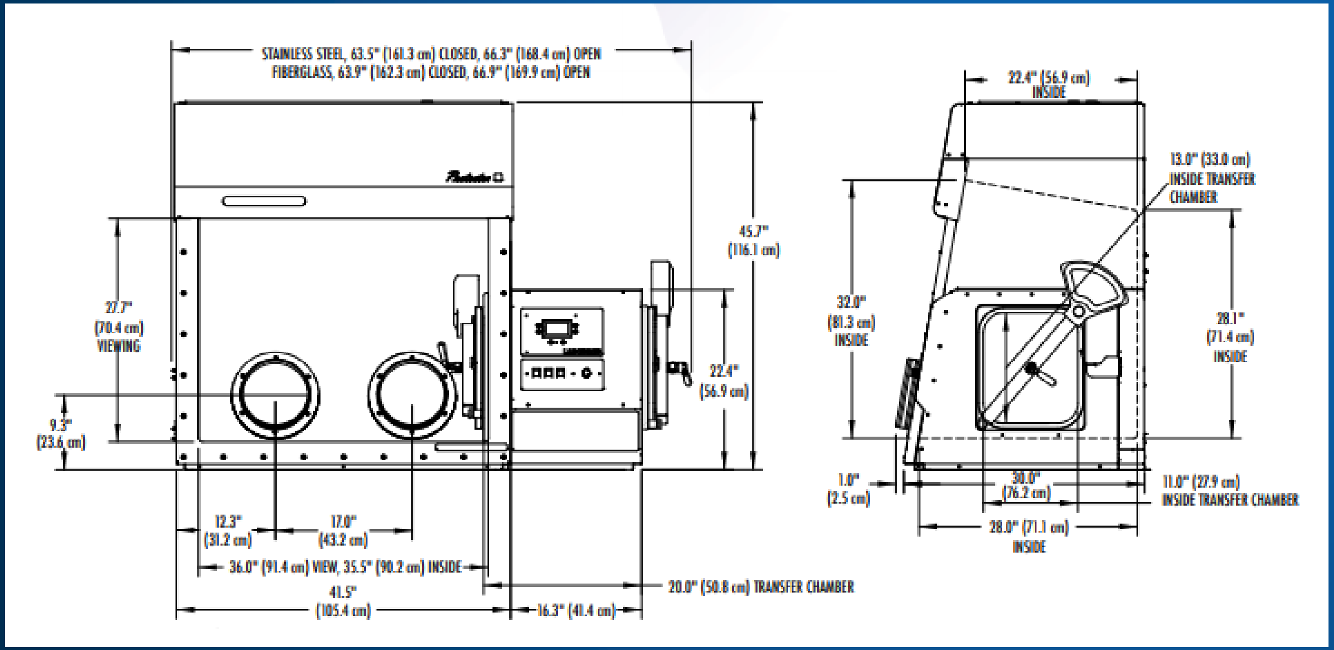
- Isotope depletion/decay analysis program with a graphical user interface (GUI) used in applications spent fuel, fissile material, and radioactive material.
- There are many selections of output including mass of each isotope after a given time as well as the photons released from the decaying isotope after a given time.
- The user set all of the parameters like mass of sample, isotopic composition, gamma spectrum, and more.
- ORIGEN (Oak Ridge Isotope GENeration) is not a stand alone program it is used within SCALE (Standardized Computer Analyses for Licensing Evaluation) which contain most of the data (ENDF) used for analysis.

Monte Carlo N-Particle Transport Code (MCNP6.2)

- Is a Monte Carlo N-Particle code used for neutron, photon, and electron transport.
- For simplicity it is a statistical program that analyzes the probability of what reaction will occur at a given energy level.
- We will be using MCNP for radiation protection and dosimetry, and radiation shielding.
- Currently we are modeling a glove box to measure the radiation that a worker will receive when handling the U-233 and U-232.

Glove Box in MCNP

- The input file of MCNP is written is a notepad++ file and ran through the a command prompt. (Pictured to the right)
- For our model of the glove box we are using the following dimensions. (Pictured below)

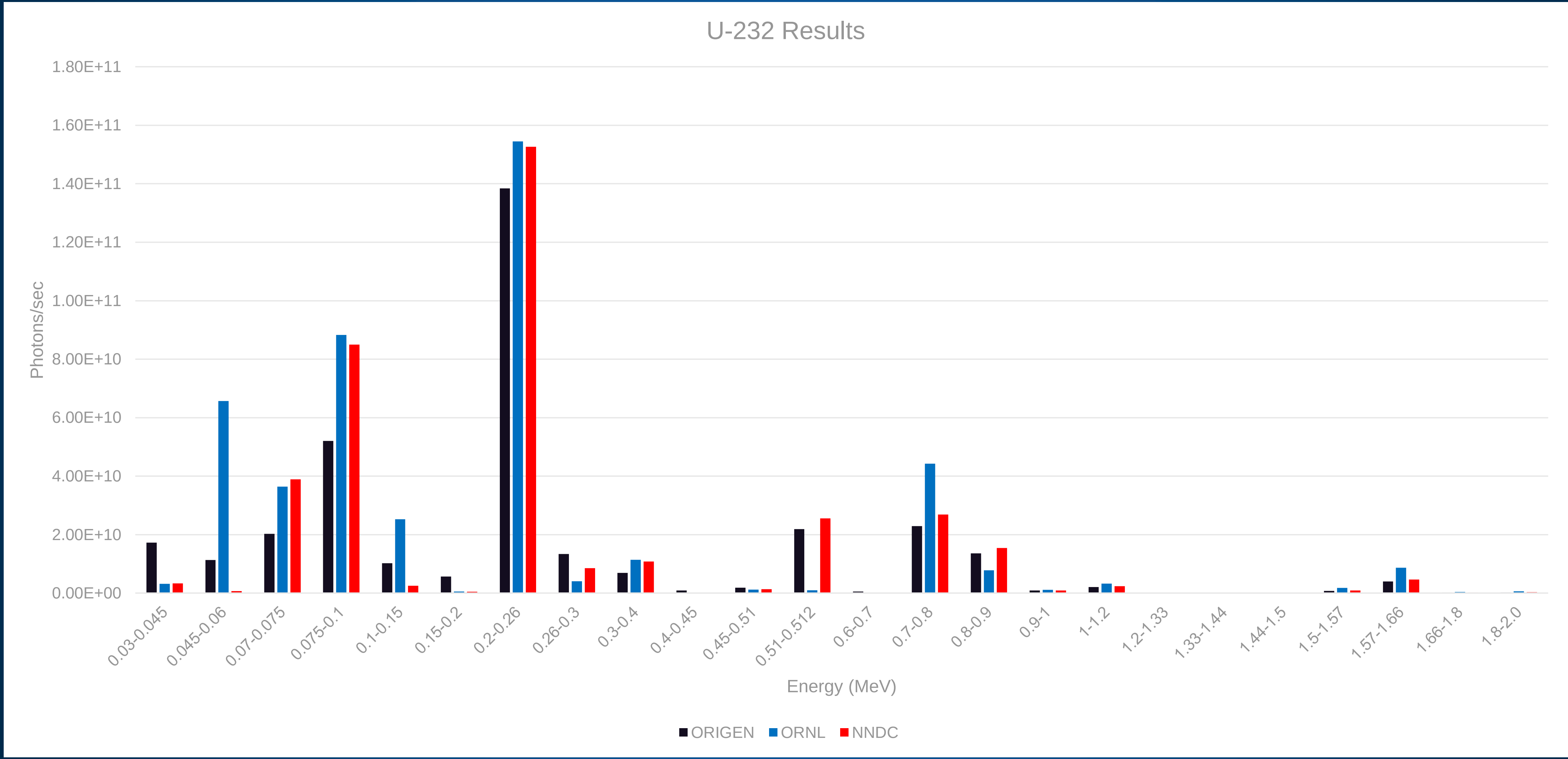



```
Glove box
1 1 -1.23 -1 3 $ right glove
2 1 -1.23 -2 4 $ left glove
4 5 -1 -3 $ right hand
5 5 -1 -4 $ left hand
5 2 -8 -6 5 $ The glove box
6 3 -0.001165 -5 1 2 $ Inside the glove box
7 4 -0.001205 6 -7 $ outside of the glove box in the system
8 0 7 $ void out of system

1 RCC -38.1 21.5 -34.45 76.1 0 0 10.16 $ the outside right glove
2 RCC -38.1 -21.5 -34.45 76.1 0 0 10.16 $ the outside left glove
3 RCC -38.1 21.5 -34.45 76.1619 0 0 10.1219 $ actual right glove
4 RCC -38.1 -21.5 -34.45 76.1619 0 0 10.1219 $ actual left glove
5 RPP -35.55 35.55 -45.7 45.7 -35.7 35.7 $ inside glove box
6 RPP -38.1 38.1 -52.7 52.7 -58.05 58.05 $ outside glove box
7 S 0 0 0 100 $ system boundary

IMP:P 0 0 1 1 0 0 0
MODE P
SDEF PAR=P POS= 0 0 0
F4:P 4 $ Cell flux
F2:P (4.1 4.2 4.3) $ Surface Area Flux
F14:P 5 $ Cell flux
F12:P (5.1 5.2 5.3) $ Surface Area Flux
M1 1000 -0.05692
     6000 -0.542646
     17000 -0.40043 $ Neoprene gloves density (1.23)
M2 6000 -0.0004
     14000 -0.005
     15031 -0.00023
     16000 -0.00015
     24000 -0.19
     25055 -0.01
     26000 -0.70173
     28000 -0.0925 $ SS 304 density (8.0)
M3 7014 $ Nitrogen gas (0.001165)
M4 6000 -0.000124
     7014 -0.755268
     8016 -0.231781
     18000 -0.012827 $ Air near sea level density (0.001205)
M5 1001 -0.081192
     6000 -0.583442
     7014 -0.017798
     8016 -0.186381
     12000 -0.130287
     17000 -0.0009 $ MS20 Tissue Equivalent density (1)
NPS 1000
```

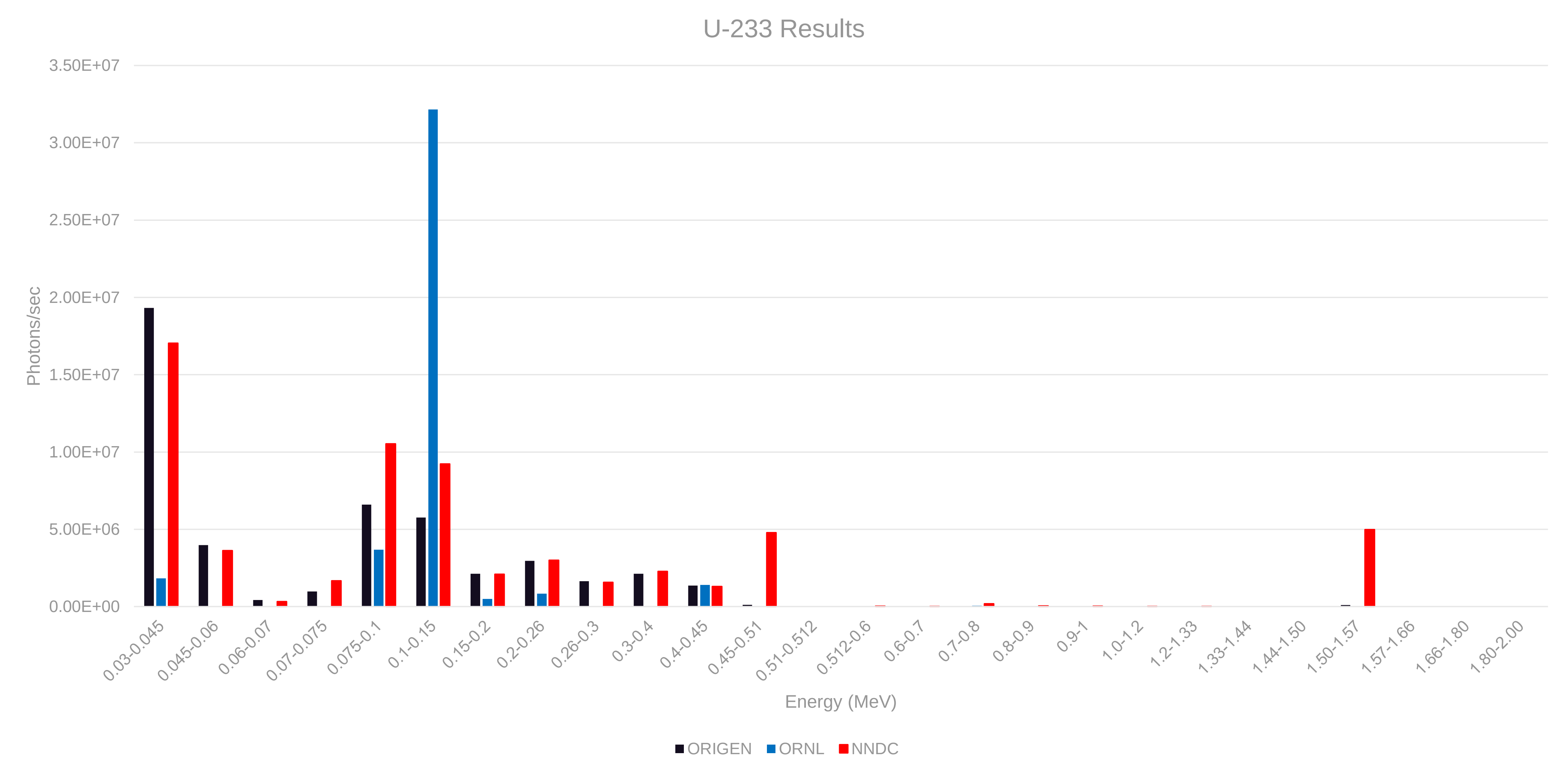
Parameters Used

- **The Uranium in the sample is 3 years old.**
- **The start mass of U-232 is 0.5 grams.**
- **The start mass of U-233 is 49.5 grams.**
- **The bin size is varied to accommodate the fluctuation in many constants like the attenuation coefficient which changes with energy levels.**

Results of U-232



Results of U-233



Future Work

- The next step is to analyze the ORIGEN output and other data files further and lower the percent error.
- Once the percent error is lowered the data then could be put into an MCNP input file.
- MCNP will output the flux of photons that are reaching the workers hands through the gloves as well as the photons that are making contact with the body through the viewing panel.
- Being we will have validated the photon data inputted into MCNP our flux calculations will be valid and we then can approximate the dose.
- Once the dose is calculated the amount of time per year a worker can be in contact can be easily found.

Acknowledgements

- My mentor Jerrad Auxier.
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Questions?